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CHAPTER TWO:
AGGREGATES IN INDIANA

Aggregates play an important role in highway construction. Without aggregate, concrete bridges and structures, Hot Mix Asphalt (HMA) pavements, and concrete pavements could not be constructed and very few roads would sustain the current loads. The use of aggregates in highway construction has literally brought the transportation industry out of the mud.

Aggregates are not used indiscriminately in construction, as not all aggregates are appropriate for every application. Some aggregates do not have the correct chemical or physical properties or the correct size or shape for the job. This chapter includes the requirements that aggregates are required to meet, the tests of INDOT, and the documentation that is required to be completed for the test results.

ORIGIN OF AGGREGATES

The three main sources of mineral aggregates in Indiana, gravel and natural sand, crushed stone, and slag, all have different origins.

GRAVEL AND NATURAL SANDS

Most of the gravels and natural sands used today are a product of the Ice Ages (glaciation). Geologists concur that glaciers may have been up to 1 mile thick. As the glaciers advanced southward, rock was scraped beneath them. When the glaciers melted, the flowing water carried the rock fragments and deposited them downstream. The scraping action of the ice and flowing waters gave the gravels and natural sands the rounded appearance.

In addition, minor amounts of gravel and sand are obtained from postglacial or modern stream deposits. This operation is called fluvial and is largely restricted to the river bars, bottom lands, and flood plains of the Ohio River and the lower reaches of the White and Wabash Rivers.

Gravel and sand are unconsolidated granular materials resulting from the natural disintegration of rocks. They disintegrated primarily from the abrading action of water or ice on rock material. Therefore in Indiana, deposits are likely to be found in stream bottoms, in terraces adjacent to streams, and in outwash plains, all of which are areas beyond the physical limits of the original glaciers.

CRUSHED STONE

Crushed stone produced within Indiana originates from sedimentary bedrock deposits. There are three general classes of rocks: igneous, sedimentary, and metamorphic. Igneous rocks were formed from hot volcanic magma--molten mineral material. Sedimentary rocks were formed from the disintegration of other rocks and organic materials. Metamorphic rocks were originally igneous or sedimentary rocks, but were changed by pressure and/or heat. Across the United States, variations of the above noted rock types are utilized for crushed stone aggregate. Sedimentary rock types, limestone and dolostone, are primarily used as construction aggregates within Indiana. Sandstone from southern Illinois, a sedimentary rock type, is permitted for use in hot mix asphalt surface courses.

SLAGS

There are four main types of slag used as construction aggregate in the state of Indiana:

1) Blast Furnace Slag -- a non-metallic material removed in the molten state of iron production. The further refinement of this blast furnace slag results in three aggregate variations: air-cooled slag, expanded slag, and granulated slag.

2) Steel slag -- a material derived from the further refinement of iron to steel.

3) Wet-bottom boiler slag -- a material which is a by-product from coal combustion at electrical generating plants. A secondary product created at these power plants is a residue in the flue gases known as fly ash.

4) Lightweight aggregate -- a material which is created as a by-product of the manufacturing process of construction brick. The primary constituent is shale, sedimentary rock.

DISTRIBUTION OF AGGREGATES

All types of aggregates are not found in every area of Indiana. The composition of each type of aggregate also varies.

GLACIAL DEPOSITS

Gravel and sand deposits are found along almost any river in Indiana, except the south-central part of the state. At one time glaciers covered five-sixths of Indiana. Figure 2-1 shows the southern boundaries of the two glaciers which moved into Indiana.

The size of the gravel and the type of minerals and rocks found in the deposits varies from place to place. As shown in Figure 2-2, the size of the gravel, in general, tends to get smaller downstream within a drainageway. Statewide, the occurrence of gravel decreases from northeastern to southwestern Indiana.

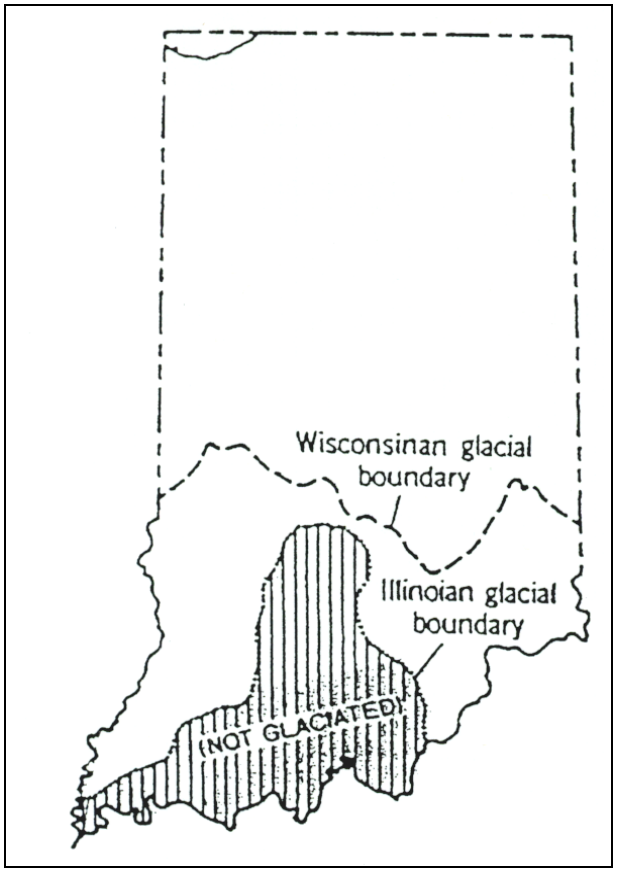

Figure 2-1. Southern Boundaries of Glaciers which moved into Indiana.

The composition of a deposit also varies from place to place. In some deposits, 10 to 20 different types of rocks may be found. Granite, gneiss, and schist (igneous and metamorphic rocks) or limestone, dolostone, chert, sandstone, siltstone, and shale (sedimentary rocks) are typically found. Porous chert, siltstone, sandstone, ocher, and shale are deleterious, meaning that the material does not perform well in certain applications in highway construction. The map in Figure 2-3 illustrates the distribution of deleterious materials around Indiana.

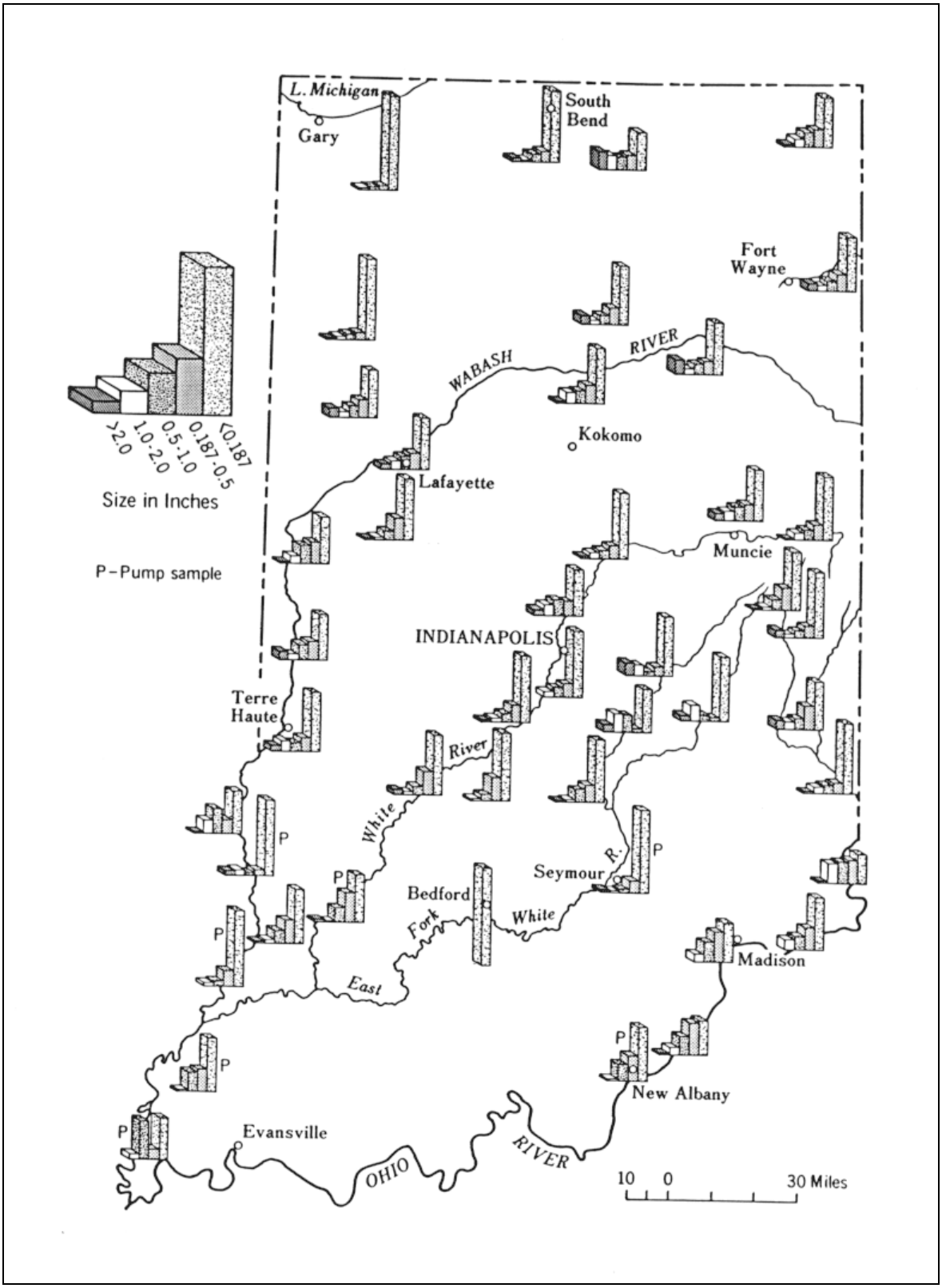

Figure 2-2. Gravel Size Distribution Map of Indiana.

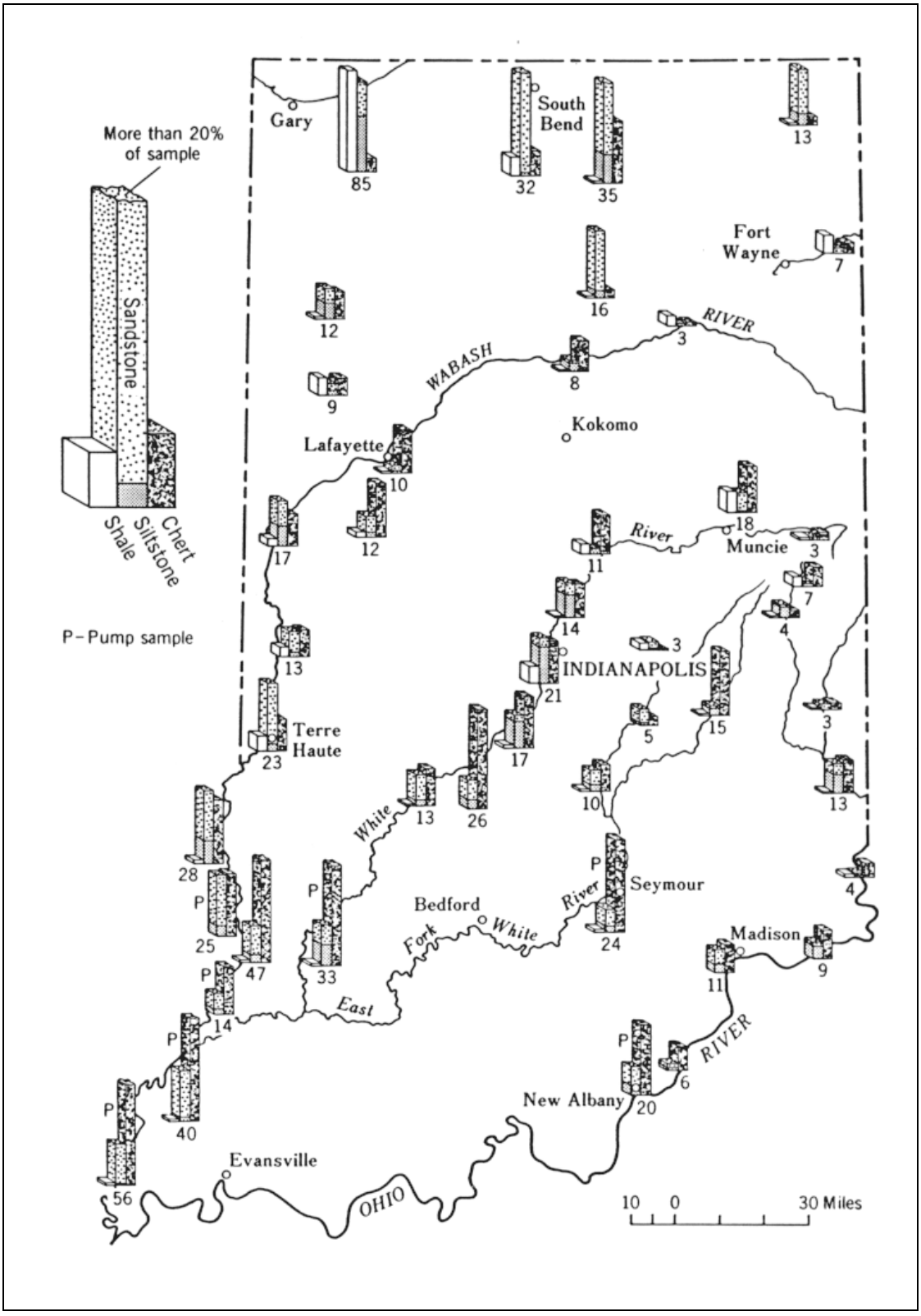

Figure 2-3. Deleterious Materials Distribution Map of Indiana.

BEDROCK DEPOSITS

As shown in the bedrock map of Indiana (Figure 2-4), the bedrock belongs to five geologic periods which are listed from the oldest to youngest: Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian.

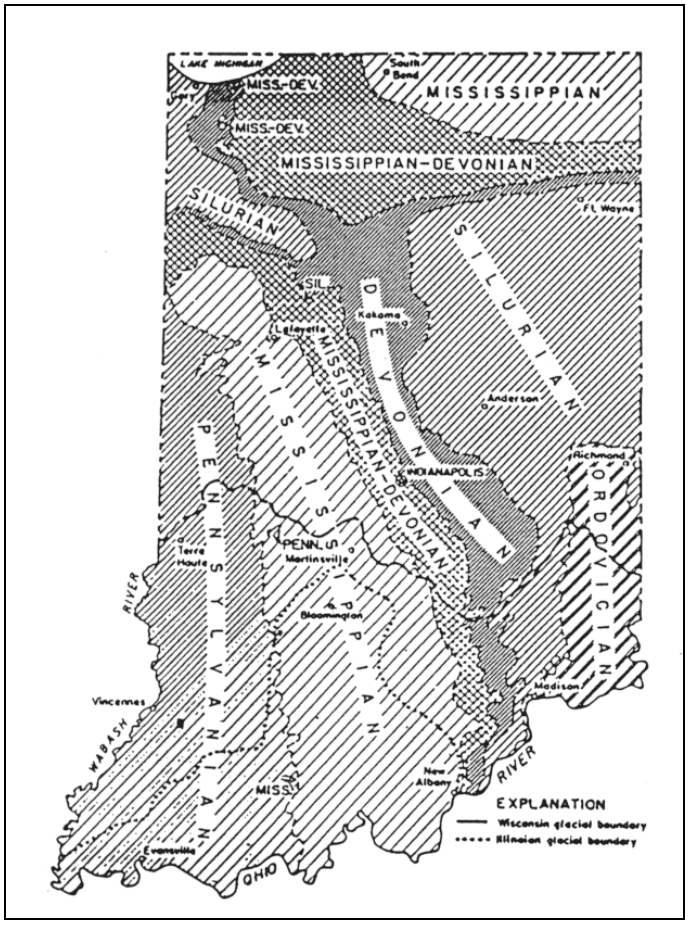

Figure 2-4. Bedrock Map of Indiana.

Comparing the map of the quarry locations (Figure 2-5), to the bedrock map (Figure 2-4), almost all of Indiana's crushed stone quarries are in areas underlain by rock of Mississippian, Devonian, or Silurian Ages. During these periods, thick beds of high-grade limestone or dolostone were formed. Rock types formed during other geologic periods are either inaccessible or do not possess the minimum quality requirements needed for highway construction.

Since most of Indiana once was covered by glaciers, the deposits left by these glaciers have also had an effect on the location of quarry sites in the state. Quarry sites are more easily developed in southern Indiana than in northern Indiana where the overburden may reach several hundred feet in depth. In the glaciated parts of Indiana, quarry sites are limited to areas where streams have eroded to bedrock or areas where bedrock was usually high in pre-glacial times, such as ancient coral reefs. Many quarries have been developed in areas where sand and gravel deposits were mined to the bedrock surface.

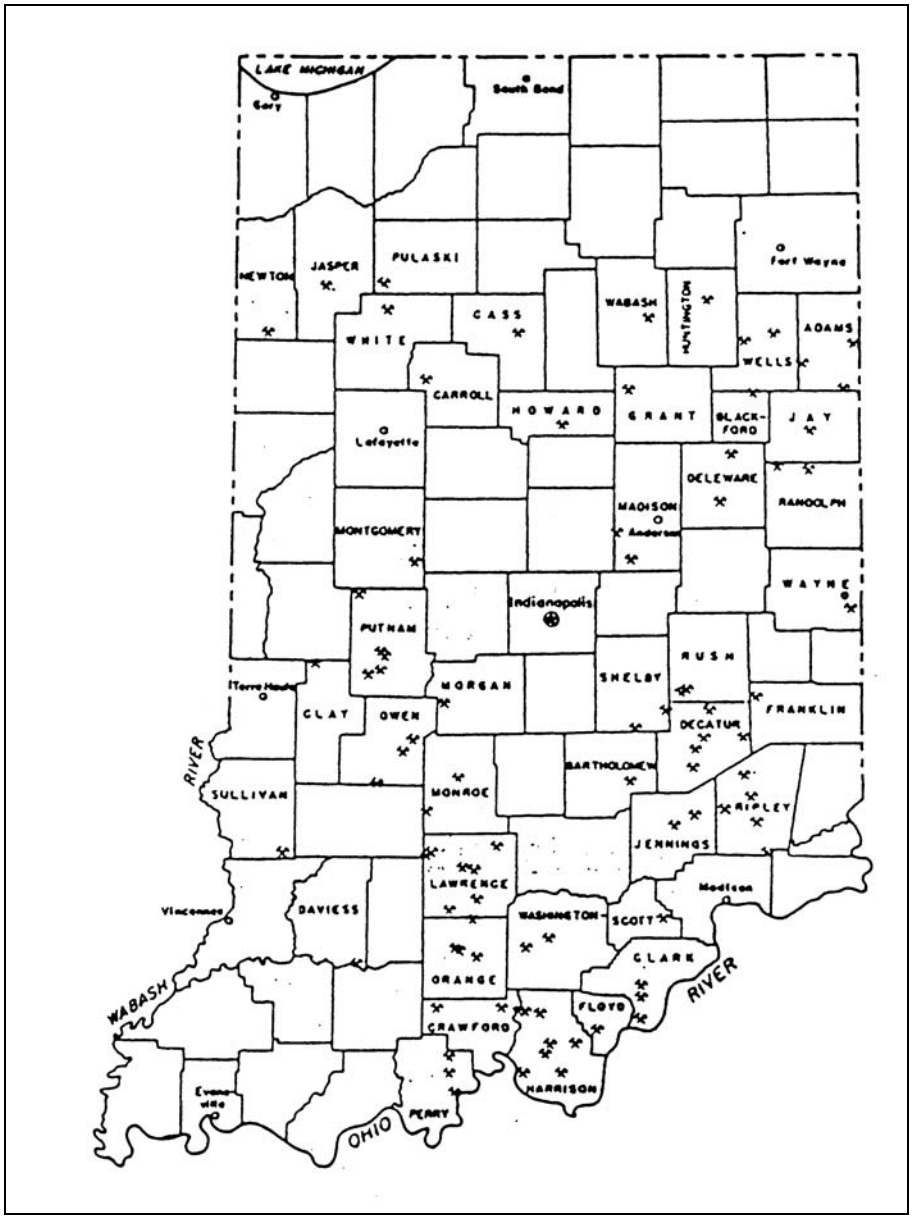

Figure 2-5. Quarry Locations in Indiana

AGGREGATE TYPES

The aggregates used in highway construction are all mineral aggregates. Aggregates are composed of a naturally occurring solid chemical element or compound formed as a product of an inorganic process. There are two distinct types of aggregate: natural, and artificial.

NATURAL AGGREGATES

Rock or stone (either term may be used) fragments which are used in their natural state are considered natural aggregates. Crushed stone, sand, and gravel are natural aggregates.

Crushed Stone

Crushed stone is produced from quarries where the bedrock is blasted (shot) with explosives and further fragmented by mechanical crushing. All crushed stone fragments are angular in shape and all faces of the fragments are created by the crushing operation.

The most common sedimentary rock types found in Indiana are limestone, dolostone, sandstone, shale, and siltstone. Only limestone and dolostone are routinely used for highway construction, although some sandstone from southern Illinois is allowed for high-friction HMA surface.

Sand and Gravel

Sand and gravel are the result of the weathering and erosion of bedrock by natural forces. The two are generally found together, in pockets deposited by a stream or a glacier. These aggregates may be mined from a water-filled pit (a deposit below the water table) or from a cut-bank deposit (a deposit above the water table). If the aggregates come from a pit, the aggregate is referred to as "pit-run" material. A cut-bank deposit is termed "bank-run" material.

Sand from these deposits are often referred to as natural sand, while sand made by crushing stone, pieces of gravel, or slag are commonly called manufactured sand.

The sand and gravel found in the deposits have a variety of assorted sizes. Further processing is required including screening, washing, and some crushing. The crushing is done to produce aggregates of the proper size.

ARTIFICIAL AGGREGATES

Artificial (synthetic) aggregates are manufactured aggregates or by-products of industrial processes. Of the artificial aggregates, INDOT most commonly uses the by-product aggregates. These aggregates are processed either from blast furnace slag, steel slag, or wet bottom boiler slag.

CLASSIFICATIONS OF AGGREGATES

Aggregates are separated into two classifications: coarse aggregates, and fine aggregates. The No. 4 sieve generally determines the difference between coarse aggregate and fine aggregate for most highway construction work.

FINE AGGREGATE

Fine aggregate is defined as aggregate that is 100 percent passing the 3/8 in. sieve and a minimum of 80 percent passing the No. 4 sieve. Natural sand and manufactured sand produced by crushing stone, steel furnace slag, air cooled blast furnace slag and wet-bottom slag are all fine aggregates.

COARSE AGGREGATE

Coarse aggregate is defined as aggregate that has a minimum of 20 percent retained on the No. 4 sieve. Crushed stone, crushed or uncrushed gravel, and crushed blast-furnace and steel slag all fall within this category.